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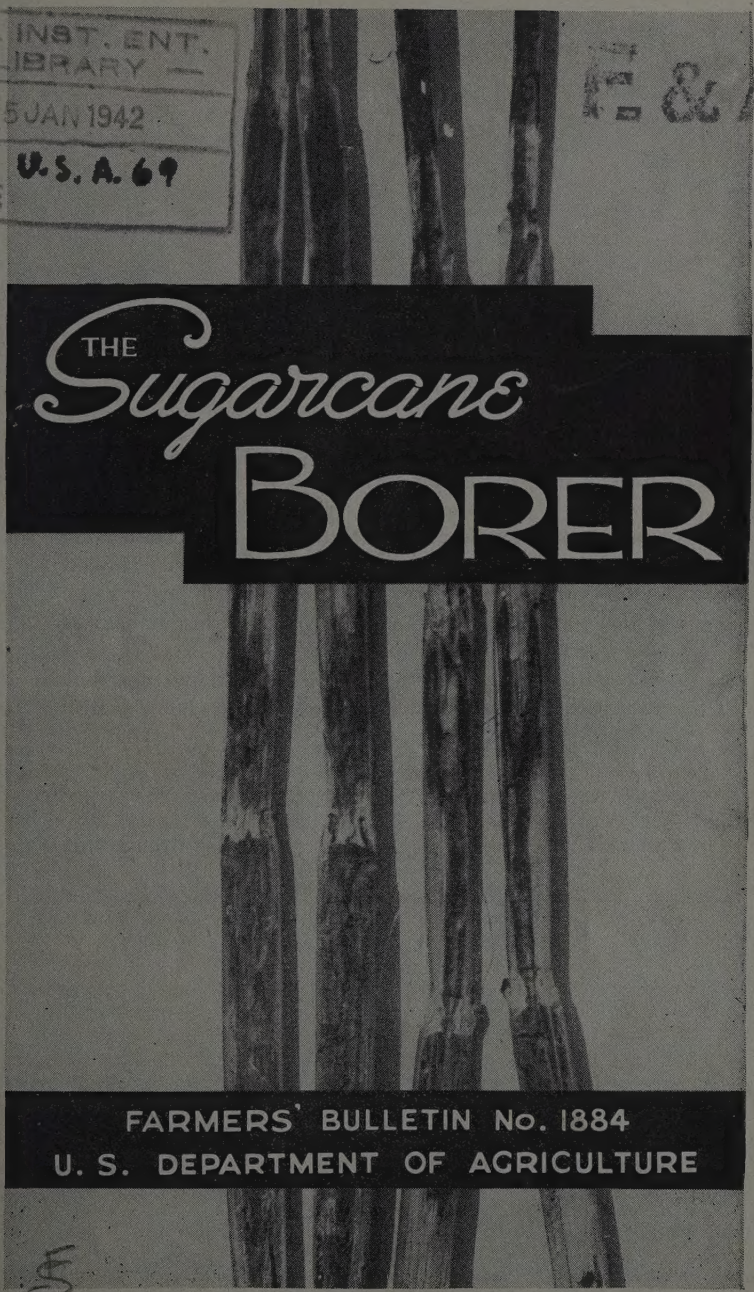

THE Sugarcane BORER

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THE introduction of new sugarcane varieties and the development of better farm machinery, the most important of which are the cane harvester and tractors suitable for cane cultivation, have changed the methods of controlling the sugarcane borer, the most important sugarcane insect. The new varieties of sugarcane produce a much larger yield, and the additional cane trash left in the fields at harvest makes borer control more difficult.

The purpose of this bulletin is to furnish the sugarcane grower with the latest available information on borer control under prevailing conditions.

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THE SUGARCANE BORER

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THE SUGARCANE BORER (*Diatraea saccharalis* (F.)),[1] which is apparently a native of the West Indies and Central and South America, was introduced into continental United States prior to 1856. Since its establishment it has been regarded as the most injurious insect attacking sugarcane in this country.

It is distributed generally throughout the Western Hemisphere from the southern portions of the Gulf States to northern Argentina. In continental United States it occurs in Florida south of a line drawn west from Daytona, in Mississippi in a strip 20 to 50 miles wide along the Gulf coast and in a small area around Centreville and south of that place, in Louisiana south of a line drawn west from Bougere through Coushatta to Zwolle, and in Texas in a strip 50 to 150 miles wide bordering the Gulf. There appear to have been few changes in recent years in the extent of the area infested.

Other closely related species of *Diatraea* that are pests of economic importance in the United States are the southern cornstalk borer (*D. crambidoides* (Grote)) and the southwestern corn borer (*D. grandiosella* Dyar). The former is distributed in the South Atlantic States from northern Florida to Maryland, inclusive. The latter is found in western Texas, southwestern Kansas, southern New Mexico, and southeastern Arizona. Neither of these species seriously damages crops other than corn, although at times both have been found attacking sugarcane.

CROPS ATTACKED AND NATURE AND EXTENT OF INJURY

The sugarcane borer attacks sugarcane, corn, rice, sorghums, and a number of wild grasses. Total losses from borer injury to these crops in continental United States have been estimated as amounting to over 6 million dollars annually.[2] In all these crops the borer

[1] Order Lepidoptera, family Pyralidae.

[2] HYSLOP, J. A. LOSSES OCCASIONED BY INSECTS, MITES, AND TICKS IN THE UNITED STATES. U. S. Bur. Ent. and Plant Quar. Cir. E-444, 57 pp., 1938. [Multigraphed.]

larva tunnels up and down inside the stalk, thus decreasing growth and sometimes causing the death of the upper part of the plant. These tunnels also furnish ready means of entrance and spread for some diseases that attack the host plant. In addition, its attacks often cause injured plants to break over, especially in high winds.

SUGARCANE

Borer attacks on sugarcane result in the following types of injury: (1) Dead hearts in young plants, (2) dead tops in older plants, (3) broken-over stalks, (4) loss in weight and sucrose, and (5) injury to seed cane.

Dead Hearts Resulting From Borer Injury

The injury known as dead heart may be recognized by the yellow, dying condition of the inner whorl of leaves, which contrasts with the healthy, green appearance of the outer and lower leaves. Similar dead hearts also result from the feeding of adults of the sugarcane beetle (*Euetheola rugiceps* (Lec.)), wireworms, and larvae of the lesser cornstalk borer (*Elasmopalpus lignosellus* (Zell.)). Dead hearts may also result from cuts made by cultivators and hoes, from injuries caused by men or work animals stepping on the young plants and breaking the brittle inner tissues. Sometimes such injuries result from twisted growth of the inner tissues. If the plant is cut and examined, borer injury may of course be easily distinguished from these mechanical injuries by the tunnels and frass and usually by the presence of the borer itself. In areas where borer infestation is moderate to heavy and where wireworms or sugarcane beetles are not abundant the sugarcane borer is usually responsible for about 60 percent of the dead hearts.

The injury develops as follows: Moths from overwintered borers deposit eggs on the leaves of the young cane plants. The young borers hatching from these eggs feed on the leaves for a few days and then bore into the plant, where they feed on the central tissues. Thus the growing shoot is gradually cut off and dies. As a result of cannibalism and other causes, usually only one borer reaches maturity in each dead heart. In Louisiana the borers of the first generation cause dead hearts in about 95 percent of the shoots attacked. Some dead hearts result from injury by borers of later generations, but after the stalks have formed joints, borer injury seldom results in a dead heart.

It is difficult to determine losses from dead hearts. Most of the injured plants do not die but form new shoots. Since these shoots are less mature at harvesttime there is certainly some loss in sucrose. As many as 1,953 dead hearts per acre caused by first-generation borers have been observed in stubble cane in Louisiana.

Dead Tops Resulting from Borer Injury to Older Plants

Injury to older plants results from somewhat the same type of feeding that causes dead hearts in younger plants. Borers attacking the stalk near the top cut off the flow of food substances to that area. This causes its death. Many of the lower buds may sprout as a result. Not only does the growth of these sprouts decrease the sucrose content of the old stalk but they are themselves usually too low in sucrose at harvest to be of any value.

Broken-Over Stalks

Borers tunneling in the stalk or circling the nodes when this hard tissue is reached often so weaken the supporting tissues that the upper part of the stalk falls over or is broken over by the first strong wind. This injury results in the loss of the upper part of the stalk. When the break occurs near the ground the stub may be left in the field during harvest. Also, when buds on the lower part sprout and grow, there is a decrease of sucrose and an increase in the percentage of undesirable gums.

Loss in Weight and Sucrose

In older plants borer injury is not so easily recognized as in younger ones unless infestation is heavy enough to cause many dead tops and broken stalks. It is usually necessary to strip off the leaf sheath to detect borer entrance and exit holes and the sawdustlike frass pushed out of borer tunnels. Borers make tunnels up and down the stalks, sometimes gnawing their way out through the hard rind and reentering the stalk at another place. Their consumption of plant material and cutting of channels that carry plant food cause decreases in the weight and growth, inversion of sugar, and spoilage through the entrance of red rot, other fungi, and bacteria into the borer tunnels and retard the maturity of the affected stalks. It is generally considered that bored cane does not keep so well after it is cut for milling as sound cane does.

On the basis of analyses of infested and clean cane made in several cane-growing countries, the loss of sucrose in infested canes, is estimated at from 10 to 20 percent. From sucrose analyses of bored and nonbored cane made at Houma, La., in 1939 it was estimated that for the varieties Co. 281, C. P. 28/19, and C. P. 29/320 a 10-percent loss in sucrose resulted when 20 percent of the joints were bored. According to annual harvesttime surveys of the Louisiana cane-growing area, the percentages of joints bored have been as follows: 1935, 8.1; 1936, 8.7; 1937, 16.1; 1938, 15.85; and 1939, 19.74.[3] [4]

Injury to Seed Cane

In Louisiana, seed cane is planted late in the summer or in the fall and is therefore subject to heavy deterioration during wet winters. The presence of borer tunnels in the cane increases this hazard, especially in any variety that is very susceptible to red rot; and if badly bored seed cane of such a variety is planted, serious losses usually result.

Losses

Losses from injuries caused by the borer, including dead hearts, dead tops, and broken-over stalks, reduction in weight and sucrose content of harvested cane, and losses from the use of bored seed cane are great. Estimated crop losses in Louisiana for the period 1912 to 1939, inclusive, have ranged from 8 to 30 percent annually. Losses in southern Florida are estimated at about half those in Louisiana, since in Florida the borer infestation is about half as severe.

[3] This survey was conducted in cooperation with the Louisiana Agricultural Experiment Station during the years 1936–38.

[4] INGRAM, J. W., and ELLISOR, L. O. BORER INJURY TO SUGARCANE IN LOUISIANA IN 1936. La. Agr. Expt. Sta. Bul. 298; 17–19, 1938.

Borer injury is usually much heavier on light soils than on heavy soils, and, except in hill sections, injury is usually greater on the higher and better-drained lands. Injury by first-generation borers in the spring is usually much greater in stubble than in fall plant cane. This difference in infestation decreases as the season advances, so that by harvesttime little difference has been found between plant-cane and stubble-cane infestations.

CORN

Larvae of the sugarcane borer attack corn in much the same manner as they attack sugarcane. Their tunneling in the stalks results in dead hearts or dead tops, or often the stalks may be so weakened that they break over. Borer larvae also may gnaw out the bud, either killing or seriously deforming the plant. In addition, they may bore through the ear shank and into the ears, permitting the entrance of weevils, and often the shank breaks or the supply of plant food is so cut off that ear development is incomplete. Then, too, borers may feed on the grain. Even where none of these more readily apparent types of injury occur, tunneling by borers may cause a decrease in plant growth and in the number and size of ears produced.

Injury to corn by the sugarcane borer is estimated at about 2½ million dollars annually. In the rice-growing section of southwestern Louisiana and southeastern Texas corn usually becomes so heavily infested by the borer that its cultivation is seldom profitable, and for this reason farmers do not grow it. This heavy infestation results from the large borer population that overwinters in rice stubble and concentrates on corn in the spring, since corn usually is the only food plant available when the moths emerge.

RICE

The sugarcane borer and the rice stalk borer (*Chilo plejadellus* Zincken) both attack rice in the Gulf States, but about 95 percent of all borer injury to rice is inflicted by the sugarcane borer.

The damage done by these borers is greater than would be suspected from casual observation, as only a small number of rice stalks are killed outright. The injury causes the panicles of the rice plants to turn white, and from these white panicles the damage done by the borers is usually estimated. Upon closer examination after harvest, however, as many as 32 percent of the stubs in large fields of rice have been found infested with borers, and it is estimated that a loss of more than one bag (160 to 220 pounds) of rice per acre has resulted from such injury. During the growing season the rice stalks may become greatly weakened by the tunneling of the borers, and heavy loss from lodging may result, especially in windy weather. In late rice many of the young plants may be cut so severely or injured just above the water line by the feeding of the numerous little borers that the top of the plant breaks off. The vitality and yield of infested plants that mature are also reduced. The damage from borers usually is heavier in large-stemmed than in small-stemmed varieties.

Annual losses resulting from sugarcane borer injury to rice in Louisiana and Texas have been estimated at over $500,000.

BROOMCORN AND SORGHUMS

The sugarcane borer attacks broomcorn, grain sorghums, and sorgos, (sweet sorghums), causing a loss estimated at $20,000 annually. The sorghums are affected in very much the same way as sugarcane and corn, since the borer larvae, tunneling in the stalks, stunt their growth, lower the production of grain or sirup, and often

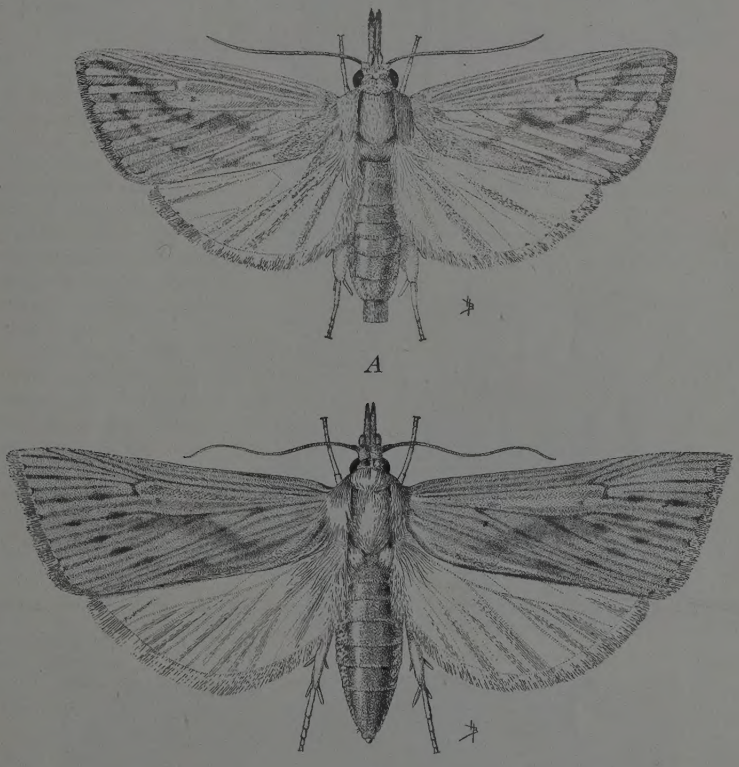

FIGURE 1.—The sugarcane borer (*Diatraea saccharalis*): *A*, Adult male; *B*, adult female. Four times natural size.

cause the injured plants to break over. Borer injury is especially damaging to broomcorn, as it may result in an almost complete loss of usable brush.

DESCRIPTION OF STAGES

The adult (figs. 1 and 2) of the sugarcane borer is a straw-colored moth having each forewing marked with a somewhat V-shaped design of black dots. The size of the moth varies with the amount of food taken by the larva, but averages an inch or slightly more from tip to tip of the spread wings.

FIGURE 2.—The sugarcane borer; adult with wings folded. Eight times natural size.

FIGURE 3.—Cluster of eggs of the sugarcane borer nearly ready to hatch. Four times natural size.

The eggs (fig. 3) are flat and elliptical and about 1.16 millimeters long. They are deposited in flat clusters on the leaf and overlap one another to form a pattern similar to that of the scales of a fish. The clusters contain from 2 to 100 or more, though the number of eggs found in a single cluster averages about 25 and is usually less than 50.

FIGURE 4.—Larva of the sugarcane borer, dorsal view. Three times natural size.

The eggs are creamy white when laid but become more yellowish as the incubation period advances, until the curled bodies of the young borers may be seen through the eggshell.

The larva (fig. 4) is yellowish white with brown spots, although in the winter these spots are often absent and the color becomes a deeper yellow. The larva is about 1 inch long when full-grown.

The pupa (fig. 5), or resting stage, ranges from light to dark brown and averages about two-thirds of an inch in length by one-sixth inch in breadth.

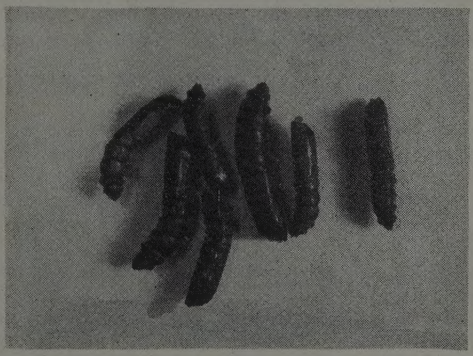

FIGURE 5.—Pupae of the sugarcane borer. Slightly enlarged.

LIFE HISTORY AND HABITS

The sugarcane borer overwinters as a larva in a tunnel in its host plant. In the spring, as the temperature rises, the larva becomes active. It extends its tunnel toward the plant surface until the covering of tissue that remains is so thin that the adult moth can easily make its way out. The larva then transforms to a pupa, from which the adult moth soon emerges. After mating, the female moth deposits eggs on the leaves of host plants. These hatch in from 4 to 9 days into tiny larvae, which feed for a short time on the leaf or in the central whorl and then bore into the stalk. The larvae spend the remainder of this stage inside the plant, where they tunnel up and down the stalks except for occasional emergence through the stalk rind to reenter at some other point. At the end of 20 to 30 days in the summer the larvae transform to pupae within the borer tunnel. The moths emerge in 6 or 7 days. There are four or five generations annually.

With the approach of cool weather in the fall the borer larvae become more sluggish and feed only on warm days. In Louisiana,

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Texas, and Mississippi borers begin to hibernate in September and October, and most of the resulting moths emerge during the following April. In southern Florida borers go into hibernation approximately a month later and emerge a month earlier. In sugarcane fields the borers hibernate in the following materials, which are named in descending order of abundance: Cane trash left on the field after harvest, young plants of summer-planted cane, seed cane, cane stubble, and wild grasses. In rice-growing areas a large number of borers hibernate in rice stubble. The number hibernating in corn is in proportion to the corn's lateness in maturing. Very few borers hibernate in early planted corn.

EFFECTS OF WEATHER CONDITIONS ON BORER ABUNDANCE

Weather undoubtedly is important in affecting borer abundance. Fewer borers pass the winter successfully if there are low temperatures and heavy rainfall during the hibernation period, as borers are killed both by freezing and by immersion in water. Late freezes in the spring, after overwintered borers have become active, are of much value in decreasing infestations. Some borer eggs and young larvae are washed from the plants by heavy rains. On the other hand, some may be adversely affected by prolonged periods of dry weather.

NATURAL ENEMIES OF THE SUGARCANE BORER

A minute wasp, *Trichogramma minutum* Riley, is of much value in decreasing borer injury. It is found throughout the area in which the borer occurs and in fact is almost universal in distribution. This parasite deposits its egg in that of the borer. The resulting parasite larva eats out the contents of the borer egg, and usually in 8 or more days the adult *Trichogramma*, instead of a borer larva, emerges from the egg. Parasitized eggs are readily distinguished as they turn black in 3 or 4 days.

In the spring the percentage of borer eggs of the first generation parasitized by *Trichogramma minutum* is very low. The percentage increases, however, with each succeeding generation of the borer until often, in many Louisiana sugarcane fields during September and October, over 90 percent have become parasitized. It is generally considered that if it were not for this parasite, losses caused by the borer might be much greater than they are. Various attempts have been made to increase the usefulness of the parasite. It was formerly thought that *T. minutum* hibernated in trash left in sugarcane fields after the harvest and that the burning of trash killed many of the parasites. Large-scale experiments conducted over a period of several years, however, have proved that the burning of trash does not affect the percentage of parasitization in the following season.

It appears that *Trichogramma minutum* would be much more beneficial if it were present in larger numbers early in the season. Attempts have been made to increase its usefulness as a parasite of the sugarcane borer and of a number of other species of host insects by breeding and releasing it in large numbers early in the year. It has been reared in large quantities on eggs of the Angoumois grain moth (*Sitotroga cerealella* (Oliv.)) and released in sugarcane fields during the period from May to August, when natural parasitization

was low and borer eggs were present on the plants. Large-scale experiments to determine the value of such mass liberations of *Trichogramma* as a control for the borer were conducted in Louisiana from 1933 to 1935, inclusive. Areas in which parasites were released, when compared with similar areas in which no parasites were released, showed no increase in percentage of parasitization of borer eggs, no decrease in percentage of infested joints or stalks, no increase in weight of cane per acre, no increase in sugar per ton of cane, and no increase in pounds of sugar per acre. Since these experiments indicate that wholesale liberations of *Trichogramma* are of no value as a control measure, colonization of this parasite as a method for borer control is not recommended. There is at present no known way of increasing the effectiveness of *Trichogramma* against the borer.

A number of other native parasites have been found attacking the borer, but none of these have appeared in sufficient numbers to be of appreciable value in controlling it.

Thirteen species of parasitic insects known to attack the sugarcane borer or related species in foreign countries, or in other sections of the United States, have been introduced into the area where the sugarcane borer is present. Of these the following have not been recovered at all or only in the year of their release: *Apanteles diatraeae* Mues., *Ascogaster quadridentata* Wesm., *Ceromasia sphenophori* Ville., *Chelonus annulipes* Wesm., *Exeristes roborator* (F.), *Ipobracon amabilis* Brethes, *Ipobracon rimac* Wolcott, *Lydella grisescens* R. D., and *Microbracon brevicornis* (Wesm.).

The tachinid parasite *Lixophaga diatraeae* (Towns.) has been found in years other than those of its introduction, both in Louisiana and Florida. Results of mass breeding and release of this fly on one plantation in Florida indicate that this practice may be of value.

Another dipterous parasite, *Theresia claripalpis* (V. d. W.), is fairly well established in a number of places in southern Florida. As many as 40 percent of the borers have been found parasitized by this species. It has been recovered in Louisiana in years following those in which it was released, but it has not yet multiplied sufficiently to be of importance in borer control.

A parasitic wasp, *Bassus stigmaterus* (Cress.), has become well established in southern Florida and is of some economic value in borer control.

Another tachinid, the Amazon fly (*Metagonistylum minense* Towns.), has recently been introduced and has been recovered in Louisiana the year following its release.

Several of these introduced parasites have proved of much value in borer control in other countries and in time may become effective in continental United States. When a parasite becomes well established it may be spread to other areas by taking cane from the colonized field and piling it alongside the field to be colonized. This method of transfer has been successful in Florida with both *Theresia claripalpis* and *Bassus stigmaterus*.

Ants attack the borer in various stages sometimes, but their value in borer control is considered to be more than offset by the increase in mealybugs and aphids which results from their husbanding of these insects. Adults and larvae of a soldier beetle, *Chauliognathus marginatus* F., are occasionally found attacking borer larvae. Earwigs have been found feeding on both eggs and larvae, and the large num-

bers of these predators found in Florida indicate that they may be of appreciable value in borer control there.

Birds are undoubtedly of much value in borer control. The Fish and Wildlife Service of the United States Department of the Interior lists the following birds as feeding on members of the family Pyralidae, to which the sugarcane borer belongs:

Eared grebe	Bufflehead	Sage grouse
Mallard	Hungarian partridge	Ring-necked pheasant
Black duck	Bobwhite	Wild turkey
Wood duck	Gambel's quail	Spotted screech owl
Canvasback	Scaled quail	Nighthawk
Road runner	House wren	Meadowlark
Tree swallow	Mockingbird	Red-winged blackbird
Blue jay	Robin	Baltimore oriole
Florida jay	Starling	Savannah sparrow
Canada jay	Palm warbler	Cape Sable seaside sparrow
Common crow	English sparrow	

Protection of these birds would undoubtedly be of value in borer control.

Fungi and bacteria have been found attacking borer larvae and pupae, but their attacks usually followed other injury to the borer. It appears doubtful that these organisms are of much value in controlling the borer.

METHODS OF DECREASING LOSSES DUE TO THE BORER

DESTRUCTION OF HIBERNATING BORERS

The borer population is always at its lowest in the spring because of the large number that die during the winter. The estimated maximum and average number of borers that survive the winter in Louisiana in various materials, based on large numbers of field counts over a period of several years, are given in table 1.

TABLE 1.—*Estimated number of sugarcane borers per acre surviving the winter in various host materials in Louisiana*

Material	Maximum number	Average number
Sugarcane:		
Stubble	76	36
Fall-planted seed cane	126	48
Summer-planted seed cane	33	12
Fall-planted young shoots	0	0
Summer-planted young shoots	122	75
Burned trash	930	217
Covered nonburned cane trash	3,744	370
Rice stubs	84,942	42,471

Borers overwintering in cane stubble usually are found above ground or at the surface of the soil in the stubs. The number of borers surviving the winter in cane stubble could be reduced by cutting the stalks lower during harvest. The additional sucrose obtained by lower cutting would alone justify this procedure.

Although a fairly large number of borers overwinter in planted seed cane, it is doubtful whether many moths resulting from these borers succeed in penetrating the usual 2 to 3 inches of soil lying above the cane to reach the surface. Field observations have indi-

cated that, owing to the longer period spent underground, about one-fourth as many borers survive the winter in summer-planted seed cane as overwinter in fall-planted seed cane. Under usual soil conditions moths are unable to emerge through more than one-half inch of soil. The small number of borers that overwinter and emerge as moths from seed cane could be reduced still further by selecting seed for planting that contains few borers. Many of the borers contained in seed cane can be destroyed by soaking such cane in water of ordinary temperature for 72 hours. The cane is not affected by this soaking, and approximately 69 percent of the contained borers are killed. This treatment may not be practicable on a large scale, but it is of special value when isolated areas of not over 5 or 10 acres are being planted.

No borers have ever been found overwintering in shoots growing from fall-planted cane, but as many as 122 and an average of 75 borers per acre have been found overwintering in shoots from summer-planted cane. The number of borers in such shoots may be greatly decreased by roguing out and destroying borer-killed plants together with the borers contained in them prior to the time frost makes such plants indistinguishable from uninfested plants, or by shaving summer-planted cane fields in March and then burning the shaved-off plants.

As shown in table 1, in cane-growing areas by far the most important source of borer infestation in the spring is the cane trash left on the field during the previous fall. The figures given in the table were obtained from areas having a borer infestation heavier than the plantation average and in varieties possibly somewhat more susceptible to borer injury than the average. Even under average plantation conditions, however, cane trash is the most important source of spring infestation on a sugarcane plantation. The cane leaves left in the fields after harvest help to protect the borers in the trash. Observations checked by comparison with the number surviving in unburned trash covered with a light layer of soil, have shown that burning this trash destroys approximately three-fourths of the overwintering borers. The effect of this has been apparent in the reduction of first-generation injury, even in small plots. More than twice as many dead hearts, resulting from injury by first-generation borers, have been found in fields where trash from the previous harvest was not burned, but was plowed under, as were found in fields where the trash was burned. It is therefore recommended that the trash be burned as thoroughly as possible.

No decrease in parasitization by *Trichogramma minutum* has resulted from burning. Experiments conducted over a period of 4 years showed the percentage of parasitization in unburned fields to be no higher than in burned fields, either in first-generation eggs or in eggs deposited later in the season. No borer eggs are available in sugarcane fields from harvest until moths emerge from overwintered borers the following spring. *Trichogramma* adults have always emerged in a short time from parasitized borer eggs collected in the field in the fall and held at prevailing field temperatures. It seems unlikely that the adults of *Trichogramma* hibernate in sugarcane trash, as there are always days and successions of days warm enough for activity during the winter. Records indicate that *Trichogramma* overwinters in the sugarcane-growing areas by continuous breeding

in the eggs of hosts other than the borer, and none of these hosts are known to oviposit in cane trash.

If equal borer control could be obtained without burning the trash and if the mechanical difficulties involved in otherwise disposing of the large volume present in the fields could be overcome, the utilization of the organic material would undoubtedly be preferable to burning because of its benefit to the soil and of its value in reducing soil-animal and root-rot injury. Under methods now available for trash handling, however, it is necessary to burn the trash in order to facilitate tillage operations and to reduce the number of overwintering borers. It is also recommended that a more thorough clean-up of pieces of millable cane in the fields, around the loading stations and sugar houses, and along roadways and railroads be made at harvest. It seems likely that a man and a cart following the cane loader could pick up enough good cane to pay for this extra operation, and, in addition, decrease the borer infestation the following spring.

Cornstalks are of minor importance as shelter for overwintering borers in the Louisiana sugarcane area. Corn usually is planted as soon as the danger of frost is past, and by August 15 the leaves are often too dry to invite new borer oviposition. Most of the borers remaining in the cornstalks produce adults before cool weather arrives. To eliminate the possibility of borers overwintering in cornstalks, this material should be plowed under or burned before winter. In the rotation system the cornstalks are plowed under in time to permit the planting of a cane crop late in September or early in October.

Borers infest a number of wild grasses, but in Louisiana Johnson grass (*Sorghum halepense* (L.) Pers.) is the only one that is abundant throughout the sugar-producing area. Since Johnson grass is usually cut several times each season, the majority of culms are too small to furnish hibernation quarters. Borers have been observed overwintering in *Panicum dichotomiflorum* Michx., but this grass is not generally abundant on most plantations. Cutting and burning all large grass culms during the winter will eliminate most of the overwintering borers in this material.

As many as 84,942 borers per acre have been found overwintering in rice stubs. Grazing with cattle, burning, flooding, or dragging and flooding of rice stubble fields will materially decrease the number of hibernating borers.

SELECTING THE LEAST INFESTED CANE FOR SEED

It is often the practice to select the poorest cane for planting and to send the best cane to the mill in order to increase the sugar yield. The use of heavily bored cane for planting has often resulted in poor stands and decreased yields in both the plant-cane and stubble-cane years. When heavily infested seed cane is planted, many buds are killed directly by the borer. Furthermore, bored seed cane gives optimum conditions for the development of red rot, which destroys other buds. Borer injury and disease destroy the reserve food supply of the good eyes; and plants coming from these eyes may not have sufficient vitality to reach the surface of the ground or may be unhealthy and slow growing.

The most lightly infested cane obtainable of the variety desired should be selected for seed. In planting the less vigorous, more

disease-susceptible varieties special effort should be made to select seed cane as free from borers as possible in order that a good stand of these varieties may be obtained. By planting cane early in August (instead of at the usual time, late in September or in October), seed cane comparatively free from infestation can be obtained without special selection, since the infestation is lighter at this time than later, and a heavier stand is normally obtained. It is becoming a fairly common practice to make special plantings for use as seed cane. Such plantings should be made, whenever practicable, in areas known to have a lighter-than-average borer infestation.

SOAKING CANE IN HOT OR COLD WATER TO KILL BORERS

An economical way of destroying all borers within cane stalks would be of much value for treating seed cane and cane to be shipped to uninfested areas. Soaking cane for 20 minutes in water heated to 122° F. (50° C.) has been found to destroy over 90 percent of all borers present; but treatment of seed cane in hot water is not recommended when applied solely as a borer control because sprouted eyes and sometimes unsprouted eyes, are killed by the treatment and the cost of the treatment would be rather high. Injury to unsprouted eyes has not resulted in Louisiana when the hot-water treatment was conducted late in September or early in October, at which time most of the cane is planted. Treatment of seed cane for 20 minutes in hot water at 52° C. to destroy chlorotic streak disease has been recommended by pathologists.[5] When this is necessary the destruction of borers by this treatment would be an added advantage.

Treating seed cane in water of ordinary temperature for 72 hours has been found to kill from 27 to 100 percent of the borers in the cane. The average mortality in 10 tests with this treatment was 68.5 percent. Treatment for 96 hours has killed from 50 to 100 percent of the borers, the average mortality being 85.4 percent in 7 tests. Germination of seed cane is not decreased by the 72-hour treatment, and there is evidence that treated cane gives a somewhat better stand than untreated cane. This measure is of value in treating seed cane for planting a few acres when these plantings are isolated and when water is available at little or no cost. There have been a number of cases in Florida where seed cane has been soaked in lakes or other convenient natural bodies of water at little or no cost and as a result a substantial reduction in borer infestation was reported.

It is evident that treatment with either hot or cold water cannot be depended on to give borer-free seed cane for planting in uninfested areas.

FLOODING FIELDS AS A BORER CONTROL

Sugarcane stubble fields are the most important source of the spring borer infestation except in the near neighborhood of rice fields. Flooding of stubble fields for 3 or 4 days after harvest kills most of the borers that would overwinter in the cane trash and in the stubs, and has been found to reduce the infestation greatly the following year. This method of control is practical only where there is little cost attached to flooding. On one plantation in Florida, where it is

[5] ABBOTT, E. V. CHLOROTIC STREAK OF SUGARCANE. Sugar Bul. 16 (20): 4–5, illus. 1938.

possible both to flood or drain the fields by gravity, flooding has been practiced for several years. Prior to the adoption of this control measure heavy losses were suffered from borer injury, but since its adoption losses have been markedly reduced. In January examinations were made of fields in which the trash had been burned and the field then flooded for 85 hours. It was found that 89 percent of all borers were dead, while in unburned and unflooded stubblefields only 19 percent of the borers were dead. In what were apparently the most completely flooded areas the mortality reached 95 percent. The subsequent stand of cane produced by the flooded stubble has apparently not been materially reduced by this practice.

PLANTING RESISTANT VARIETIES

Varieties of sugarcane grown in the United States prior to the general distribution of the P. O. J. varieties in 1924 exhibited little difference in the amount of borer injury sustained. With the increase in acreage of the P. O. J. varieties it soon became evident that they sometimes varied widely in the extent of borer injury. P. O. J. 213 was severely infested, P. O. J. 234 was moderately infested, and P. O. J. 36 and P. O. J. 36M were comparatively lightly infested.

Borer injury to varieties commonly grown in Louisiana during recent years is given in table 2. Replicated plots of these varieties were examined in variety field tests conducted by the Bureau of Plant Industry of the United States Department of Agriculture in each of several locations in the sugar-growing area of Louisiana.

TABLE 2.—*Percentage of joints bored by the sugarcane borer in various commercial varieties of sugarcane*

Year	Varieties					
	C.P. 29/116	Co. 281	C.P. 29/320	C.P. 28/11	C.P. 28/19	Co. 290
PLANT CANE						
1936	24.9	17.2	17.4	23.3	20.2	11.2
1937	28.1	25.8	25.7	24.2	26.1	16.9
1938	35.5	30.6	29.4	24.8	24.1	20.8
1939	40.9	33.4	32.4	31.1	25.7	26.8
Average	31.4	26.0	25.5	25.3	23.8	18.1
FIRST-YEAR STUBBLE CANE						
1936	16.3	12.7	11.3	12.9	13.9	8.6
1937	24.6	21.1	18.3	18.7	17.7	12.8
1938	31.9	25.1	22.9	23.4	20.0	17.6
1939	37.5	29.9	28.9	25.4	22.5	26.4
Average	26.5	21.3	19.4	19.5	18.1	15.2
Average for plant cane and stubble cane	28.9	23.6	22.4	22.4	20.9	16.7

In each experiment the percentage of joints bored was determined for 20 stalks of each variety in each of 5 plots, this giving 100 stalks of each variety for examination. The plants in 5 plant-cane and 5 stubble-cane experiments were examined for borer injury during each year of the period 1936-1938, inclusive, and those in 3 plant-cane and 3 stubble-cane experiments were examined in 1939.

Variety C. P. 29/116 has consistently proved to be the most heavily infested of the commercial varieties, both as plant cane and as stubble cane. From the standpoint of insect control this variety should not be planted in areas subject to fairly heavy borer injury. The variety Co. 290 has proved to be the least subject to infestation, and in addition suffers very little loss in sucrose from the borer injury that does occur. With 20 percent of the joints bored, other varieties have been found to have lost about 10 percent in sucrose. Where agronomically satisfactory, it is recommended that Co. 290 be grown in areas subject to fairly heavy losses from borer injury. All the other varieties included in table 2 suffered about average borer injury.

Variety C. P. 29/103, which was recently released for commercial production in Louisiana, has been more heavily infested, in counts to date, than C. P. 29/116. The planting of either variety should be avoided in areas of heavy borer injury.

In cooperation with the Bureau of Plant Industry of the United States Department of Agriculture search is being made for additional resistant varieties and for parent varieties which, in crosses, transmit resistance to their progeny.

CUTTING OUT AND DESTROYING BORERS IN DEAD HEARTS

Cutting out and destroying borers in dead hearts of cane shoots has long been a practice on some plantations. Laborers walk through the fields in the spring and cut out all the shoots they see that show a yellow, dying condition of the inner whorl of leaves. If the borers in these dead hearts are not killed they will continue to develop in the rogued plant and produce moths. Care should be taken to cut off the shoots below the lower end of the borer tunnels in order that the larvae or pupae may be included in the cut portions. As previously stated, about 60 percent of all dead hearts result from borer injury. Experiments have shown that with ordinary plantation labor about 96 percent of the borers in the cut-off dead hearts are destroyed by this treatment. Observations also indicate that about 90 percent of all the borers in a field are destroyed when dead hearts are cut out at the time first generation-injury is occurring. In cutting out dead hearts at the time of injury by borers of the second generation, probably less than 50 percent of the borers in the field are removed. By this time most of the plants are so large that in many instances borer injury does not result in a dead heart.

The cost of cutting out dead hearts four times with ordinary plantation labor in four large-acreage experiments conducted in 1939 ranged from $1.60 to $1.90 per acre. If dead hearts are to be rogued out, the field should be gone over not less than three and not more than four times at 10- to 12-day intervals beginning in May when dead hearts resulting from first-generation borers become numerous and when large borers are first found in dead hearts. Roguing for first-generation borers should be done during May and the first half of June.

Since only a small percentage of the borers of later generations are obtained by roguing and since cane apparently suffers more injury from later roguing, it is recommended that no dead hearts be cut out in attempting to control later generations. Typical dead hearts

are not often found in second-generation injury although in jointed plants this injury sometimes results in dead tops.

CHEMICAL CONTROL

The relatively high value per acre of sugarcane as compared with that of other field crops and the fact that borer infestation appears to remain consistently much higher in some areas on every plantation than in others, have indicated excellent possibilities for chemical control. A number of years ago lead arsenate dust was experimented with as a control for first- and second-generation borers in the spring but failed to give satisfactory control. In 1925 the Louisiana Agricultural Experiment Station announced favorable results in controlling borers from experimental dusting of sugarcane with sodium fluosilicate during the summer. In the summer of 1926 experiments were conducted by the Bureau of Entomology with sodium fluosilicate and barium fluosilicate dusts applied from muleback, but neither of the materials gave borer control.

A total of 5,000 acres of sugarcane were dusted by airplane from 1 to 3 times during August, September, and October of 1927 with 2 different brands of sodium fluosilicate. Examinations to determine borer mortality were made in from 4 to 15 days after the dust applications. For all larval stages the actual percentage of borer mortality was 28.2, as compared with 8.6 percent in nondusted cane, leaving a net kill from the dust of 19.6 percent. The maximum percentage of mortality for young larvae outside the stalks amounted to 35.6 percent, however. In 13 experiments the dust failed to reduce the borer infestation at the time of harvest.

Previous experience showed that the borer was difficult to reach with insecticides after it had entered the stalk and that it was almost impossible to cover all parts of the plants after midsummer because of the tall, rank growth it had attained by that time. Consequently more recent experiments in control with insecticides have been conducted on first- or second-generation borers in the spring when the cane is smaller. In cooperation with the Louisiana Agricultural Experiment Station a number of chemicals have been tested since 1937.[6] Calcium arsenate and dual-fixed nicotine each failed to give satisfactory control. Synthetic cryolite dust, from the time it was first used in 1937 to January 1940, when the last comparable results were obtained, has consistently given from 90- to 95-percent control of the first generation in small replicated plots when applied at weekly intervals for 4 weeks at the rate of 10 to 12 pounds per acre per application. A large-acreage experiment conducted in 1939 gave further indication of the value of this material as a borer control. Cooperative experiments are being continued to determine its practicability for commercial use.

MEASURES NOT RECOMMENDED

Trapping Moths

Many different chemical baits have been used experimentally in an attempt to attract and trap the moths, but without success. Piles of trash placed in the field also failed to attract moths for daytime hiding.

[6] ELLISOR, L. O., and INGRAM, J. W. EXPERIMENTS WITH INSECTICIDES IN THE CONTROL OF THE SUGARCANE BORER, DIATRAEA SACCHARALIS (F). Internatl. Soc. Sugar Cane Technol. Cong. Proc. (1938) 6: 693-705. 1939.

Lights were observed to attract numbers of borer moths, but most of these were males. Trapping with lights has not been found of economic value as a borer control.

Planting a Trap Crop of Corn

It is apparent that if corn or any other infested crop is handled in such a way that any borers contained in it are destroyed, these borers, which might have attacked another crop, would thereby be eliminated. For this reason it has been suggested that corn planted near cane might attract moths from the cane and that their progeny might then be destroyed by feeding the corn to stock, by soaking it in water, or by otherwise treating the cornstalks to destroy the larvae. This trapping practice is not recommended because it was found that farmers were unable to determine the time when such trap crops should be destroyed. If moths were allowed to emerge, the practice might actually serve to increase rather than decrease the moth population, since there is a higher percentage of borer survival in corn than in cane. Where farmers plan to use green corn for feeding, it would of course be advisable, from the standpoint of borer control, to use up the most heavily infested portion first.

SUMMARY OF RECOMMENDED CONTROL MEASURES

The following control measures are considered practical and are recommended:

(1) Make a more thorough clean-up of pieces of millable cane during harvesting operations to eliminate the overwintering of borers in these large pieces.

(2) After harvesting, thoroughly burn the trash as soon as it is dry, to destroy overwintering borers.

(3) During the winter cut and burn all large grasses in which borers might hibernate in and around fields.

(4) Cut lower when harvesting cane to decrease the number of borers overwintering in cane stubs and to increase sucrose production.

(5) Flood fields for 3 or 4 days after harvest, if this can be done with little expense, to kill overwintering borers.

(6) Select seed cane as free from borers as possible to secure a better stand and to decrease the number of borers overwintering in planted canes.

(7) For small plantings, if it can be done with little expense, soak seed cane in cold water for 72 hours to kill the borers in it before planting.

(8) Where agronomically practical, plant the resistant variety Co. 290 in areas of heavy borer injury and refrain from planting the susceptible varieties C. P. 29/116 and C. P. 29/103 in such areas.

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